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PROFESSOR H. W. CONN

PROFESSOR H. W. CONN

W. M. ESTEN

Connecticut Agricultural College, Storrs, Connecticut

It is a pleasure to write of the life and work of a teacher with whom the writer was so pleasantly associated in both teaching and investigation for sixteen years. Professor Conn takes his place among the prominent biologists of the nineteenth century. His achievements are particularly interesting and noteworthy because they cover the pioneer period of the branches of science which he made his specialties. He was at the front in the great advance made in biological science in the past thirty years, but at no time lost his deep interest in the social welfare of all mankind. His dominant work was in dairy bacteriology, although he taught and expressed some of the most profound principles of agricultural science in the relation of bacteria to crop production. He was always on the right side of all public and social problems, although he was given ample opportunities to testify on the questionable side of public welfare controversies at large remuneration.

As a teacher, perhaps, he reached his highest achievement, is attested to by more than two thousand students who came under his influence. His personal magnetism, polished English, interesting illustrations and illuminating suggestions captivated his listeners. His teaching was masterful, and with him it became an art. He was able to make a difficult subject easily understood, and the breadth of his conception of the subject at hand was remarkable. This breadth of view acquired from very extensive reading made a lasting impression on the mind of the student. No one could attend his lectures without acquiring a wider and truer view of life and its problems. In laboratory teaching his pleasant suggestiveness and persuasive leading stimulated the student to acquire knowledge for the mere pleasure of it. His was the method of Agassiz. He instructed his assistants to give as little help as possible until the student had reached the

limit of his own observation. "Let them find it out for themselves," was the trite saying which proved that he well knew the true methods of acquiring an education. He was able by clear and concise directions to conduct laboratory sections in general biology for over seventy students at a time.

As a member of society he could converse entertainingly and instructively on almost any topic of interest. He had the courage to attack any problem, no matter how difficult, and always labored at its solution with great perseverance.

The most interesting phase of his life's work was accomplished in dairy bacteriology. At the time of the founding of the Storrs Agricultural Experiment Station by Dr. Atwater in 1889, Dr. Conn commenced the studies of the organisms which ferment milk. In the first report of this Station will be found an account of this early work. In 1890 he isolated bacterial enzymes from pure culture which when added to milk in powder form caused a curdling and subsequent digestion. In the fall of 1891 was commenced the study of the organisms that ferment ripening cream. As each kind of bacteria was isolated it was given a number. When the exhibit was installed at the World's Fair, Chicago, in 1893, to show the effect of bacteria in the production of flavor in butter, some thirty-five varieties of organisms had been isolated. No. 2 at that time produced the best flavor, and No. 16 the worst. The latter was sickening, brackish, and persistent. These two organisms were used daily at the fair in the ripening of cream for churning. An upright case was installed in the exhibit. This case held about forty large test tubes which showed the effect of pure cultures growing in milk. The exhibit attracted a great deal of attention and the city papers published long descriptions of it. During the same summer eight or nine varieties of bacteria were added at the fair to the list, most of them isolated from a can of milk from Uruguay. Among them was the remarkable and famous "B 41." Following this came the development and application of cream starters which gained practically universal use throughout the United States. At the same time blue litmus gelatin was developed for the isolation of acid bacteria. From this experi-

mental work in the bacteriology of milk has been built up a fairly extensive science of dairy bacteriology.

As director for several years in the Summer School at Cold Spring Harbor, Long Island, his capabilities reached their highest achievement. The writer's memories of him at this place are the most cherished of all. We were a happy family. All restraint of forced attendance was removed, but we could not afford to miss a single exercise. His lectures here, as elsewhere, were models of presentation and scope. As there was no church in the immediate vicinity, Dr. Conn would address us Sundays on some appropriate topic.

In his interest of scientific agriculture for the welfare of mankind, and with keen perception and prophetic vision, he presented the problems many years ago which we are today trying to solve. In 1882 Atwater and Woods demonstrated that the legumes were capable of fixing definite amounts of atmospheric nitrogen. Nine years later Professor Conn explained the function of bacteria in the fixing of this nitrogen in the root nodules of the legumes. To the writer a solution of these problems for the benefit of the world appears to be a most worthy goal.

Dr. Conn's influence as a Christian gentlemen who was always an exponent of right teaching the profound philosophy of correct living, will long make itself felt among his many students, associates and friends.

WATER REQUIREMENTS FOR MILK PRODUCTION

A. C. McCANDLISH AND W. G. GAESSLER

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The importance of water in the animal dietary is appreciated and the special emphasis required by the water supply of the dairy cow can be easily recognized from the fact that milk consists of approximately 87 per cent water and 13 per cent of solid constituents. Water has many important physiological functions to perform, chiefly in connection with the solution and transportation of nutrients and the regulation of body temperature, and in addition to these maintenance requirements the milch cow demands large quantities of water to be used in actual milk production.

PREVIOUS WORK

A considerable amount of work has been done on the water requirements of the dairy cow but these investigations have been conducted mainly with a view of noticing the influence of the temperature of the drinking water on the total water consumption and milk production of the animals, but in reviewing the literature only the actual ratio of the water consumed to the milk produced will be considered.

It was reported by Armsby(1) in an experiment with one cow that when fed fresh grass she drank 234 pounds of water for each 100 pounds of milk produced while when the same grass was fed dried, 421 pounds of water, in addition to that in the feed, was required for the production of 100 pounds of milk.

In investigations on the warming of water for cows during winter King(4) found that on the average 407 pounds of drinking water were required for each 100 pounds of milk produced, while Collier (2) stated that cows consumed 468 pounds of water in feed and drink for each 100 pounds of milk produced.

It has been shown by Eckles (3) that the water consumption of two cows was in practically the same ratio as their milk production, the consumption of drinking water being 273 pounds and 221 pounds respectively per 100 pounds of milk produced.

TABLE 1

Animals used

	COW				
	No. 78	No. 91	No. 187	No. 189	No. 230*
Breed	Jersey	Ayrshire	Guernsey	Holstein	Ayrshire
Date of birth	5/10/09	9/2/07	3/29/10	6/9/12	4/30/12
Age	7y. 57d.	8y. 305d.	6y. 98d.	4y. 28d.	4y. 101d.
Date fresh	3/27/16	3/13/16	1/12/16	11/6/15	8/4/16
Days fresh	102	116	177	244	7
Date bred	5/10/16	7/7/16	6/14/16	5/29/16	
Days bred	58		23	39	
Initial weight pounds	850	950	1040	1260	1040
Final weight pounds	820	880	1010	1170	1030

* Cow 91 was replaced by cow 230.

TABLE 2

Moisture contents of feeds

FEED	WATER
	per cent
Grain mixture	8.65
Oats and Canada field peas	64.42
Alfalfa	54.47
Alfalfa	59.48
Sudan grass	67.46
Amber cane and cowpeas	79.85
Amber cane and cowpeas	78.83
Soybeans	69.94

The general presumption is that drinking water is essential for dairy cows even when on a succulent ration. Though this is true in the majority of cases it does not always hold as on some occasions the physiological requirements of the cow for water can be otherwise supplied. In the report of three years

work with dairy cows Lauder and Fagan (6) showed that where large quantities of roots—up to 112 pounds per day—were fed and the grains were given as wet mashes, the cows continually refused to drink water, showing that enough for their needs was supplied in the ration.

The work of Larsen (5) and his associates has shown that for each 100 pounds of milk produced 432 pounds of drinking water or a total of 570 pounds of water in feed and drink was required.

EXPERIMENTAL WORK

This work was undertaken to determine if possible the amount of water, in addition to that in the feed, which was required for

TABLE 3

Feed consumption and milk and butterfat production

	COW					TOTAL
	No. 78	No. 91	No. 187	No. 189	No. 230	
Days in trial	50	25	50	50	15	190
Average live weight, pounds	834	918	1,024	1,224	1,039	1,014
Soiling consumed, pounds	2,604	795	2,734	3,115	987	10,235
Grain consumed, pounds	250	162	250	250	91	1003
Water drank, pounds	3,109	2,544	3,352	3,706	1,320	14,031
Milk produced, pounds	972	705	991	875	462	4,005
Fat produced, pounds	44	26	42	34	19	165

milk production when the cows were receiving succulent feed during the hot dry weather of summer. The trial lasted for fifty days beginning on July 7, 1916 and, of the four cows originally used, one had to be replaced as she did not agree with the necessary confinement. The data given concerning the cows is calculated, where necessary, to the first day of the experiment.

The ration fed consisted of the soiling crops being used in the general herd feeding—oats and Canada field peas, alfalfa, amber cane and cowpeas, and soybeans—with a grain mixture of 3 parts cracked corn, 2 parts ground oats, 1 part cotton-seed meal, 1 part wheat bran, and 1 part old process oil meal.

The animals received all the soiling they would consume, a record being kept of the amounts used daily by each individual,

while the grain rations were controlled by the milk and butterfat production of the animals.

Water was offered to the animals twice daily and they were weighed before and after watering so that a record of live weight and water consumption could be obtained. Salt was given at free will.

Moisture records were kept on all feeds consumed so that the amount of water consumed by each individual could be calculated.

TABLE 4

Consumption of water and dry matter and production of milk

	COW					TOTAL
	No. 78	No. 91	No. 187	No. 189	No. 230	
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Dry matter consumed	984	460	1,021	1,145	307	3,917
Water in grain	22	14	22	22	8	88
Water in soiling	1,850	483	1,943	2,199	763	7,238
Drinking water	3,109	2,544	3,352	3,706	1,320	14,031
Total water consumed	4,981	3,041	5,317	5,927	2,091	21,357
Milk produced	972	705	991	875	462	4,005
Drinking water per 100 pounds milk	320	361	338	424	286	350
Total water per 100 pounds milk	512	431	536	678	453	533
Total water per 100 pounds dry matter	506	661	521	518	681	545

Individual variations, in the consumption of soiling, grain and water, occur which correspond fairly well with the variations in milk production. The individual cows also showed variations from day to day in their appetite for feed and water.

The large allowance of water in the feed is apparent but even more noticeable is the water consumed in addition to this. From this work it was not possible to differentiate between the water requirements for maintenance and those for production but it is evident that milk production is intimately related with water consumption. In spite of this there were fairly wide individual variations in this relationship due largely to the fact that

varying climatic conditions, especially temperature, caused marked changes in water consumption. There was also a quite regular relationship between water consumption and the amount of dry matter eaten.

SUMMARY

Water consumption is all important in the case of the milk producing cow. When soiling crops and grain are fed an average of about 350 pounds of water in the feed will be consumed for each 100 pounds of milk produced and in addition about 200 pounds of drinking water will be needed, making a total water requirement of practically 550 pounds per 100 pounds of milk produced under summer conditions.

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THE MINERAL METABOLISM OF THE MILCH COW

E. B. FORBES

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The cow is foster-mother of the human race. This relation, older than the art of writing, grows in prominence as a factor in nutrition with our advance in the science of living; and on both physiologic and economic grounds we anticipate continued increase in the contribution of the cow to the human diet.

These grounds, for this expectation, are, that the cow is by far the most economical producer of proteid nutriment; that among proteins in general those contained in milk possess a maximum nutritive value; that milk possesses other important growth-promoting principles the exact nature of which is as yet unknown; and that no other food carries such an abundance of mineral nutrients of desirable kinds and combinations. No other food has an equal value for the general purpose of health insurance.

Since milk is preeminently a proteid food it is natural that the proteid requirement of cows should have been worked out with great elaboration, and that successful milk production should depend on a practical recognition of the cow's imperative need for the proteid raw material which she is to transform.

The fact that the cow is also unparalelled as a producer of mineral nutriment, and that her mineral food requirments must be of a corresponding order, appears to have been overshadowed by the more prominent facts as to her nitrogen metabolism; and we have not been obliged to study the cow's mineral metabolism since in the provision of her more obvious requirements we have incidentally and unintentionally done fairly well in providing the necessary mineral substances. In this day of rigorous searching for the true inwardness of things, however, we should no longer delay a careful examination into the terms on which the cow conducts her extensive mineral exchange.

[1]Paper read at the Annual Meeting of the American Society of Animal Production at Ames, Iowa, Dec. 28, 1917.

During the past three years the main line of work of the Department of Nutrition at the Ohio Agricultural Experiment Station has been an investigation of this subject. A year ago I presented to this Society a progress report of this work. We now have additional evidence which clears up the field to such an extent as to warrant a further statement of the case.

This program of investigation consisted of three experiments, with six cows in each. There were three experimental periods in the first test, and two in each of the others. Our conclusions rest, therefore, on forty-two individual studies. In each case we made complete mineral analyses of food, milk, urine and feces. These data make it possible for us to determine, in each case, whether the cow was gaining or losing in the amounts of the several mineral constituents of the body.

The cows were all unregistered Holsteins of essentially pure breeding. As an indication of their character as milk producers —the average daily yield of milk during the first test was 36 pounds, and during the second and third, about 47 pounds. They were good, common, profitable cows; better than the average, but of a quality readily attainable by selective breeding. The results, therefore, apply to practical milk production.

The rations were composed of normal foods in practical combinations. Sixteen such rations were studied. Corn was always used as the principal concentrate; with this we used commercial protein supplements such as wheat bran, cottonseed meal, linseed oilmeal, distiller's grains and gluten feed. Corn silage was fed in 11 of the 16 rations. The hay used was clover in 8 rations, alfalfa in 7 and timothy in 1. To rations compounded from such feeds we added mineral supplements of the following kinds; common salt, steamed bone flour, precipitated bone flour, calcium carbonate, calcium lactate and calcium chloride.

As much food was given as would be cleaned up without waste. The amount of food was usually just about sufficient to maintain live-weight during the liberal milk production, but there were slight gains in weight with more than half of the cows. As a further indication of the plane of nutrition, there was protein storage in 29 out of the 42 balances, or 70 per cent of the cases.

The cows therefore, were well nourished on the best of foods; the results are not in any case due to general underfeeding. The cows which gained in weight did not differ appreciably, in their mineral metabolism, from those which lost a little weight.

Now as to results—asking you to take for granted the voluminous statistical data of this study, and its extended scope, I shall call attention to only a few of the more obvious conclusions and to their practical significance.

Probably the most generally significant fact which has come out of this study is the demonstration that the status of the milch cow with reference to her mineral metabolism is distinctly different in degree from her status as to protein and energy metabolism; that the selective improvement of the milch cow has proceeded unevenly, as to the several functions involved, the capacity to assimilate the organic nutrients required for milk production having outrun the capacity to assimilate the minerals; thus during ordinarily liberal milk production, without regard to the protein metabolism, and in spite of protein storage and gain in live weight, cows commonly draw upon their bones for greater amounts of the constituent minerals than they are able to assimilate from the ration. We derive these conclusions from the balance data for calcium, magnesium and phosphorus.

In the first experiment, nitrogen was retained by every cow in all three periods. At the same time calcium and magnesium were lost in every case, and phosphorus was lost in 15 cases out of the 18. The greatest calcium loss occurred in period I, during the feeding of a ration composed of timothy hay, corn, corn silage and cottonseed meal. In later periods, the calcium intake was increased from two to two-and-a-half times by the substitution of clover for timothy hay, but the calcium loss was reduced very little. These cows, in need of calcium, and supplied with an abundance (largely in clover hay), were unable to utilize it.

In the second experiment the basal rations, fed in period I, were very rich in calcium; all contained either clover or alfalfa hay. The calcium, magnesium and phosphorus balances were all negative. In the second period the mineral intake was still

further increased by the feeding of steamed bone flour or calcium carbonate. In this period phosphorus balances became positive, in response to the increased intake of this element; magnesium remained negative in 5 cases out of 6, while the outgo of calcium, as usual, was in every case greater than the intake. This storage of phosphorus must have occurred in the soft parts, since the loss of calcium indicated a continued withdrawal of this element from the bones.

The third experiment was similar to the second; but the calcium content was increased in the basal ration by dropping out corn silage and using alfalfa as the only roughage. In the other rations the calcium content was still further increased, to about six times the quantity contained in the timothy hay ration of the first experiment, by the addition of calcium lactate, precipitated bone flour or calcium chloride. The unsupplemented rations caused invariable losses of calcium and phosphorus, and losses of magnesium in 5 cases out of 6. The supplemented rations in which we fed large amounts of readily soluble calcium compounds did not cause improved retention of mineral substance. All balances of calcium, magnesium and phosphorus were negative.

In this series of three experiments we exercised our best ingenuity to compound rations containing maximum amounts of calcium, magnesium and phosphorus, and then increased the quantities present by the addition of large amounts of mineral salts; still phosphorus was lost in 79 per cent, magnesium in 95 per cent and calcium in 100 per cent of the balance periods.

We have investigated several possible causes of the limited capacity of cows to utilize these minerals. Thus our results show that it was not due to lack of proper proportion among the mineral nutrients of the rations: nor to deficiency of common salt from which is formed the hydrochloric acid of the gastric juice; nor to difficult solubility of the supplements used, since even the water-soluble calcium lactate and calcium chloride were poorly utilized. The limiting factor must reside in the process of assimilation of the mineral nutrients by the bones.

It is true that most of the losses of minerals which we have demonstrated were small, in comparison with the extent of the

cow's mineral stores; and that these overdrafts would be repaid later in the period of lactation, when the milk flow, and therefore the draft upon the mineral reserves of the skeleton, would have become sufficiently reduced—provided the conditions of feeding were favorable. The practical bearings of this investigation consist of the application of the facts to the less favorable conditions which are often unavoidable in practice.

Another point made clear by our studies is the large measure of independence which exists in the metabolism of the several elements studied; thus calcium, magnesium and phosphorus, on account of their occurrence together in such quantities in the skeleton, might be expected to manifest a close interrelationship in metabolism, but in this investigation we found calcium and magnesium to an appreciable extent independent of each other, while phosphorus, by virtue of the considerable quantities contained in the soft parts, was sometimes retained during periods in which both calcium and magnesium were lost.

Nitrogen and sulphur commonly appeared to follow the same laws, as would be expected an account of their association in the proteins; but this was not invariably so, since in 9 cases out of the 42 the signs of the balances differed; that is, one of this pair would be stored while the other was given off in amounts greater than the intake. These differences probably depend upon the considerable variation which exists in the relative amounts of nitrogen and sulphur in the nitrogenous structures of the body, having in mind especially hair and flesh.

The lack of a close relation between nitrogen and the minerals of the bones, in their metabolism, is conspicuous. Bone starvation may proceed for some time without seriously affecting the gross body metabolism; but as to the effects of negative balances of the mineral elements of the bones on the more specialized functions of the body, we have almost no direct and satisfactory evidence.

It thus appears that the qualitative character of metabolism is highly variable; the body does not gain and lose in each of its constituents at a definite proportional rate; but rather, it exhibits a surprising degree of purposive metabolism adaptability.

As confusing a situation as any developed by our inquiry is due to the obtaining of negative balances during periods of excessive intake; thus the elimination of a nutrient in amounts greater than the intake may signify either deficiency in the food, or the unloading of previously absorbed stores in the face of continued superabundant supplies. Our mere measurement of intake and outgo leaves us without a clue as to what these transfers signify in biochemical terms. It would appear that we have not appreciated the long-continued and extensive transfers of mineral nutriment which are set in motion by changes of rations.

I suspect that we shall not really solve the problems of this field until we have series of balance periods covering the whole of the life process of interest. Such a program, in the field of mineral metabolism, would be very expensive, since complete ash analyses of all substances involved are required by the complicated interrelationships which exist between the mineral elements.

The most difficult part of such an investigation is the safe application of the results to practical affairs,—difficult because the environment of the animal is composed of such a complication of influences that it is impossible to determine the proportionate contribution of each of them, especially of the obscure and intricate facts of mineral metabolism; and also because, on account of the supreme importance of mineral metabolism, the animal is so wonderfully protected by mineral reserves and other safety provisions that unfavorable effects of treatment are slow to appear and are difficult to demonstrate in a clear-cut manner.

We have determined that liberal milk production involves a certain degree of impoverishment of the skeleton in mineral substance. This is necessitated by the fact that the cow is unable to assimilate minerals as rapidly as she must liberate them. What should this fact mean to the practical man?

Now let us consider the conditions occurring in practice coincident with this loss of mineral substance. For the present we shall be obliged to use our unaided practical judgment as to the probability of essential connections between these practical conditions and the mineral losses, and the extent of the contribution of these mineral losses to the production of the unfavor-

able results. Our general ground for assuming that there is an essential relation between this loss of minerals and concurrent unfavorable states of nutrition is that this loss, be it great or small, subtracts just so much from the capability of the organism to meet further like demands. This disadvantage comes to have an added significance during periods of stress, when the slight loss observed under optimum conditions may become a large one, and when the effects of any loss may be magnified by the critical character of the animal's nutritional situation.

By systematic correspondence with professors of dairy husbandry and veterinary science and with state veterinarians, and by a study of the literature, I have obtained a fair idea of the intelligent opinion in this country on the practical aspects of this subject. I would observe, however, that any such record of opinion is of greater value in raising questions than in settling them.

There is general agreement that sterility is common among milch cows, wherever large numbers of them are brought together in an intensive program of feeding, breeding and milk production, and that this failure to breed is becoming more prevalent. Much current opinion relates this situation to contagious abortion alone, but others, who would be considered as competent to judge of the facts, are positive that a large proportion of the cases must be due to the operation of some other important and unexplained factor. It is reported on the best of authority that occasionally whole herds will fail to breed, during a limited period, apparently because of their state of nutrition, there being no evidence of contageous abortion.

At the same time there is a belief, so prevalent that we may regard its truth as established, that failure to breed is decidedly common, though by no means invariable, after especially heavy and protracted milk production, which we have learned calls for overdrafts at the mineral bank. It is also the prevailing opinion that failure to breed is more prevalent among dairy than among beef cows, and that the higher the dairy development of the cow the more frequently will there be difficulty in getting her to conceive. It is the prevailing belief that this physiological

disturbance is an effect of the combination of intensive milk production, heavy feeding and the restraints of an unnatural environment.

In the literature we find several references to the prevalence of malnutrition of the bones following seasons of excessive heat and drouth. This condition is related to the deficient mineral content of the forage, due to subnormal transpiration of mineral-bearing moisture from the soil. By laboratory studies I have found that there may be such an effect of limited water supply on the mineral content of plants, but I do not discover any general opinion that drouth leads to malnutrition of the bones. It is well known, however, that the partial starvation which is caused by seasons of drouth and food shortage is followed by increase of sterility and abortion. Any general injury of forage crops which results in loss of vitality in the cattle has like consequences.

It is also generally understood that gross overfeeding, overallowance of protein, or any marked lack of balance in the ration, due to excessive proportion of certain feeds, even though they possess great nutritive value, may cause sterility and abortion; thus cottonseed meal, peanuts and velvet beans, when used to excess, are believed to cause sterility and abortion; and even alfalfa, the very cream of forage plants, has been the cause of much complaint on the same score, when it is used to the practical exclusion of other feeds. The case against alfalfa has not been established, but many men whose interests are involved consider this a live problem. Of course this is quite without bearing on the normal use of alfalfa. No roughage has a greater general usefulness. Its content of mineral nutriment is at least among the highest, and it has the reputation of producing large bone in calves, colts and poultry.

It has been reported that dairymen who use slacked lime to sweeten the mangers after feeding corn silage have less trouble with sterility than do others who do not follow this practice.

The direct effect of protracted deficiency of mineral nutriment is malnutrition of the bones. This is common in swine, wherever exclusive cereal feeding is practiced, but, the country over, it is rare in cattle; that is, it does not commonly reach the acute stage

at which it is recognized. It is reported, however as quite prevalent in southern Alabama, and is said also be to found in parts of southern Mississippi, in Florida and in the state of Washington. In the Alabama situation the soil is sandy, and contains very little lime. The cattle are on the ranges where legumes, if present at all, are scarce. As soon as these cattle are put on velvet beans and other farm crops in the fall they recover and come out in good condition. Here it is noticeable that cows are more commonly affected than are suckling calves, but the disorder is not entirely confined to the cows.

This disorder has been found in a great variety of situations, but most commonly in regions of unfertile sandy soils, or soils of granitic origin, especially if these be worn by long cropping with insufficient fertilization.

We must not lose sight of the fact, however, in connection with the comparative rarity of acute malnutrition of the bones in cattle, that our anxiety is not especially to feed in such manner as to prevent this malady, any more than our personal anxiety at meal-time is to escape death by starvation; rather, it is our desire so to feed our animals, as well as ourselves, as to maintain a maximum state of efficiency, which in the one case is as far removed from malnutrition of the bones as in the other from general starvation.

We have as yet made no experimental studies of the practical application of the results of this investigation, but from my present understanding of the matter I would offer the following suggestions to the dairy farmer.

Get your farm into a high state of fertility, and treat the soil, if necessary, so that it will grow legumes; then grow them, making as liberal use as is profitable of fertilizers containing calcium and phosphorus.

Consider with care your meadows and pastures; they are often neglected; if the soil is not rich, the mineral nutrients in pasture grass may be doubled by fertilization.

Build up the mineral reserves of your cattle by growing them largely on leguminous roughage or on pastures containing an abundance of legumes; and allow them exercise, as much as they

incline to take. Muscular activity increases the avidity of bone cells for mineral salts. Malnutrition of the bones of calves is often due half to character of feed and half to confinement.

Feed leguminous roughage during milk production; and give the cow a chance to refund mineral overdrafts by continuing the liberal feeding of leguminous roughage during the latter part of the period of lactation, and during the dry period, before the birth of the next calf.

Use as large a proportion of roughage in the ration as seems practical and profitable.

If you are short of leguminous roughage and must depend on corn fodder, straw, or hay made from grasses, or if on any other account there is reason to believe that your cows are not receiving proper bone food, give them bone flour. If they are already in good order there will be no marked change in condition, but the feeding of bone flour will help to keep them at their best, and is good insurance.

We have not yet determined the best method of feeding bone flour. We have fed 2½ ounces per head per day mixed with the grain, but it may be better, and all that is necessary, to allow cattle free access to this preparation. This I hope to learn at an early date.

The results of this investigation, therefore, do not indicate the desirability of radical departures from those methods of dairy cattle management which are practiced by the most successful dairymen, but they do illuminate the field in a way to add to our resourcefulness in meeting the exigencies of practice by rational and discriminating modifications of procedure. Furthermore, the facts, as we are finding them, contribute to the weight of evidence in favor of good general agricultural practice.

AN EXCEPTIONAL CASE OF MILK SECRETION AND ITS BEARING ON THE THEORIES CONCERNING MAMMARY DEVELOPMENT

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The factors responsible for the development and functional activity of the various glands and organs of the body have always been of keen interest to the scientist and also to the layman. Perhaps in no domain in the entire field of physiology has there been so much speculation, so many theories with little or no scientific foundation, as are found both in and out of the recorded literature on this subject. To discover the source of the stimuli causing mammary hypertrophy and development and those initiating and responsible for the continuation of milk secretion have likewise been the object of much research in the last decade.

Normally the alveoli (the true secreting tissue of the mammary glands) are not present in virgin animals and do not develop unless the animal becomes pregnant; at which time they develop slowly at first, but with increasing rapidity toward the latter end of the gestation period.

That this development is not stimulated through the central nervous system has been shown by researches of Goltz and Ewald (1), Ribbert (2) and Pfister (3) in which mammary glands that were severed from all possible nervous connections developed during pregnancy and secreted milk at parturition. Since the advent of the "hormone doctrine," by Baylis and Starling, investigators have been prone to believe that the growth and secretion of the mammary gland is stimulated by a hormone elaborated by some gland or organ of the body. While most of them believe that the stimulation is through the blood stream by a substance in the nature of a hormone yet they do not agree as to the source and the organs elaborating this excitant.

Lane-Claypon and Starling (4) carried on extensive researches in order to determine whether the foetus, the uterus, or any of the uterine appendages were responsible for the production of the mammary hormone. They injected an extract of these various parts into virgin rabbits and obtained mammary hypertrophy only in the experiments where the extract of the bodies or viscera of foetuses were injected. They therefore advanced the view that the developing foetus elaborates a hormone that stimulates the growth of the mammary gland and inhibits the secretion of the same; that the prime incentive of milk secretion is the abolition of this inhibitory action by the removal of the foetus by parturition or abortion.

C. Foa (5), Biedl and Konigstein (6), and Aschner and Gregoriu (7) repeated the experiments of Lane-Claypon and Starling and obtained similar results and in the main accepted their conclusions. Ashner and Gregoriu, however, concluded that the placenta also produces a substance stimulating mammary growth. O. O. Fellner (8) has obtained a marked growth of the mammary gland of a virgin rabbit and the formation of true glandular acini by the injection of placental extract, and consequently considers the placenta as the source of a mammary hormone.

K. Basch (9) transplanted the ovaries of a pregnant dog into a young virgin dog and obtained two weeks later an increase in the size of the mammary gland and in six weeks a marked hypertrophy of the same. Eight weeks after the transplantation, as a result of the injection of placental extract, he obtained milk secretion. He therefore concludes that the ovaries are the source of the growth promoting substance of the mammary glands and considers the placenta as the seat of a galactogogue hormone. He has recently patented a process for the preparation of placental extract for use as a galactogogue.

Ancel and Bouin (10) carried on extensive researches on the rabbit, an animal that does not have a spontaneous ovulation, an ova only being shed as a result of the stimulus of coitus. They bred rabbits to bucks with the vas deferens cut, thus obtaining a corpus luteum from the ruptured graffian follicle without the animals becoming pregnant. The corpus luteum thus formed

would increase in size for about fourteen days and then decline. They observed a similar growth in the mammary glands of these rabbits and called this period of growth the "constructive, or kinetic period." In a pregnant animal there is a second period "the phase of secretory activity" which is more regressive in character and prepares the gland for milk secretion. They consider the first phase as being due to the influence of the corpus luteum while the second is under the influence of the "myometral gland," the presence of which, they claim to have demonstrated in the walls of the pregnant uterus.

Frank and Unger (11) have arrived at similar conclusions in regard to the activity of the corpus luteum. Hammond (12) has also demonstrated that the first period of mammary growth may be due to the activity of the corpus luteum. He does not agree with Ancel and Bouin in view that the "myometral gland" is responsible for the second period of growth. He has failed to find this supposed gland in most of the pregnant animals examined and is inclined to believe that so called "myometral gland" is only some foetal epithelial cells and not a true gland. He observed a correlation between the growth of the mammary gland in pregnant rabbits and the increase in size of the corpus luteum through both the first and last stages of mammary growth. In "pseudo pregnant" animals, in which the corpus luteum has been formed without the animals becoming pregnant, he observed a cessation of mammary growth correlated with the decline of the corpus luteum at the end of the first period of mammary growth. By the removal of the foetus from pregnant rabbits at this period he obtained a similar decline both in the growth of the mammary glands and the corpus luteum. The retention of the placenta after the removal of the foetus did not maintain the growth of either the corpus luteum or the mammary glands. From these results he has concluded that the corpus luteum controls the growth of the mammary gland for both the first and last stage of its growth, and that the developing foetus is responsible for the maintenance of the corpus luteum during the latter part of the gestation period and therefore indirectly responsible for the development of the mammary glands during this period.

In support of this theory we have the work of Marshall and Halnan (13). They have shown that there is a "psuedo-pregnant" period in the bitch during which time the uterus and the mammary gland undergo a pronounced post-oestrous development under the influence of the corpus luteum.

While these various theories of the development of the mammary gland have good experimental evidence in their support yet we find instances of milk secretion that are inexplainable by any of them. There are numerous instances in which young animals have been brought into lactation by being suckled or having the udder manipulated. In these instances it would seem that the mechanical stimulus was all that was required to cause sufficient growth of the mammary gland to permit of milk secretion. Sometimes at birth we have a secretion of a fluid known as "witches milk" which is qualitatively similar to milk. This secretion however occurs without a development of the mammary glands.

The following is a case of milk secretion in which a suckling kid spontaneously commenced to secrete milk without having reached sexual maturity, and without udder manipulation or any other known stimulus to mammary growth.

The subject was a three fourth saanen doe kid born May 2, 1917. She was allowed to suckle her mother and was not suckled by any other kid. Since the nearest buck was four miles distant she could not have been bred even if she had been of age. When less than four months old she was observed to have a very well developed mammae and on September 6, 1917, when four months and four days old this development was so striking that the udder was examined and found to contain a fluid. This fluid was milked out and analyzed and proved to be perfectly normal milk. The kid was milked at intervals usually a week or so apart and for months continued to give normal milk. In one instance there was a lapse of nineteen days between milkings and on this occasion the largest yield ever obtained was realized. (300 cc.) A goat secreting milk in a normal lactation would have undoubtedly stopped lactating if left so long without being milked. As the table below will show, the longer the inter-

val between milkings the larger the yield of milk obtained in one milking.

The following table contains a record and the analyses of the milk from this kid since September sixth. From it the normal character of the milk can be clearly seen.

Analyses of milk from a virgin doe kid

DATE	PERCENTAGE COMPOSITION OF MILK				SUGAR	QUANTITY OF MILK	REMARKS
	Fat	Protein	Ash	Total solids			
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*cc.*	
September 6	4.20	3.60	0.84	13.32	4.68	110	1917, Kid four months and six days old
September 15	4.40	3.58	0.82	13.44	4.61	90	
September 22, 23, 24	4.32	3.53	0.84	13.22	4.53		Composite
September 29	4.78	3.36	0.81	13.52	4.57	90	
October 3	4.52	3.32	0.75	13.56	4.97	110	
October 5	5.60	3.43	0.80	14.20	4.37	75	
October 13	5.41	3.51				130	
October 29	4.82					185	
November 11						240	
November 21						295	
November 29						175	
December 2						100	
December 11	4.17	3.94	0.78	13.09	4.20	175	
December 17	4.70	4.08	0.80	13.87	4.29	125	
January 1, 1918	4.87					220	1918
January 12	5.17					260	
January 31	4.60					300	
February 9	6.66					175	
February 16	4.40					185	
February 23	4.40	4.06	0.76	13.30	4.08	190	

The writer is unable to state the origin of the stimulus causing the mammary gland to develop to a stage where milk secretion was possible. It could not have been the corpus luteum since secretion occurred before her first period of "heat" hence there could not have been a corpus luteum. This also eliminates the possibility of any foetal or placental stimulus. Since it was before sexual maturity it is not probable that the ovaries were responsi-

ble. This suggests the possibility that some of the internal secretory glands of the body such as the pituitary (hypophysis cerebri), may have a far more important part in mammary development and milk secretion than is generally conceded. The pituitary body has been shown to increase in size during pregnancy. That an extract of this gland has galactogue properties has been shown by the work of Ott and Scott (14), Schafer and MacKenzie (15), Hammond (16), Hill and Simpson (17), Hill (18), Shafer (19), and also Gaines (20), have brought forth good experimental evidence that its action is muscular in character; yet the work of Hammond (16), Simpson and Hill (21), and Hill(22) give evidence of a true glandular action, indicating that it is true galactogogue. That the pituitary body plays a very important part in the sugar and calcium metabolism of the body is now well established. Whether or not this or any other internal secreting gland of the body is responsible for the stimulation of the mammary gland of this kid is not known but the other theories of mammary growth and secretion fail to offer an explanation. It is usually difficult if not impossible to bring young virgin animals into lactation by slight manipulation of the udder yet occasionally we find one that can very easily be brought into lactation by this means. There is at present a lactating virgin heifer in the Maryland Experiment Station herd that was brought into lactation in this manner. A few years ago Dr. Buckley of the Maryland State College brought a mule into lactation by udder manipulation. Milk was obtained from the mule for months afterward.

That there was considerable development of the mammary gland of kid 4 is shown in figure 1. This photo was taken on October 13, 1917. Figure 2 was taken at the same time and while the kid was being milked. Figure 3 shows the kid trying to suck its mother while it is being milked. This was taken March 6, 1918, when the kid was ten months old and had been secreting milk six months.

It is also worthy of note that none of the milk secreted by this kid resembled colostrum. I have no record of an animal being brought into lactation without becoming pregnant where colos-

FIG. 1. KID SHOWING CONSIDERABLE DEVELOPMENT OF MAMMARY GLAND

FIG. 2. SHOWING THE KID BEING MILKED

FIG. 3. SHOWING THE KID SUCKLING ITS MOTHER WHILE IT IS BEING MILKED

trum has been secreted. Colostrum secretion must be caused by some special stimulus due to pregnancy and is apparently not associated with the commencement of milk secretion, as was formerly supposed, unless there is an accompanying pregnancy.

SUMMARY AND CONCLUSIONS

Our present knowledge of the factors controlling the development of the mammary glands and the activities of the same does not afford an explanation of all cases of milk secretion. This is especially noticeable in the case of secretion of normal milk by a suckling doe kid four months old. This kid had not reached sexual maturity so any theory of mammary growth or milk secretion involving the ovaries, corpora lutea, foetus or placenta is not appliable. The udder of this kid had not been massaged, suckled or treated in any way to stimulate its growth or secretion. It is possible that some other of the internal secreting glands have a prominent part in regulating the growth and secretory activity of the mammary glands. There is some evidence in favor of the theory that the pituitary body (hypophysis cerebri) may function in this way.

In milk secretion resulting from a normal parturition the non-removal of milk for a period of nineteen days would result in a discontinuance of the secretion. The non-removal of milk for this period of time in the lactating kid did not inhibit the secretion of the same.

The occurrence of colostrum immediately after parturition must be due to some stimulus or control resulting from the conditin of pregnancy since, it does not occur in lactation not associated with pregnancy.

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CATTLE CALLIPERS

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In the measuring of cattle for experimental purposes the fundamentals demanding greatest attention are accuracy, speed, and convenience. It was found by the Dairy Husbandry Section of the Iowa Agricultural Experiment Station in conducting work requiring the skeletal measurement of a considerable number of animals that much time was required in making these determinations with any degree of accuracy.

The feature which caused the greatest delay was the clamping and releasing of the moveable arm on the calliper as the clamp was controlled by a thumb screw, and to avoid this difficulty a standard and two callipers were constructed according to the accompanying designs and specifications. The complete set is illustrated in figure 1, while figure 2 shows the details of the clamp used on each moveable cross-arm.

SPECIFICATIONS

The graduated bars and the cross-arms are made of ½-inch hard maple finished with shellac, while the plates used to connect the fixed and moveable cross-arms with the graduated bars are of ⅛ inch brass. All graduations are in centimeters.

Standard. This consists of a graduated bar and a moveable cross-arm. The graduated bar has a basal plate of ⅛ inch brass, is 2⅛ inches wide and 175 cm. long. The moveable arm, controlled by a clamp, is 2 inches wide and 50 cm. long from the graduated face of the upright bar to the tip, and is fitted on its upper surface with a small spirit level.

Large calliper. The graduated bar, which is 2 inches wide, is fitted with one fixed and one moveable cross-arm. It measures 100 cm. from the inner edge of the fixed arm to the tip, while the cross-arms are also 2 inches wide and measure 40 cm. from

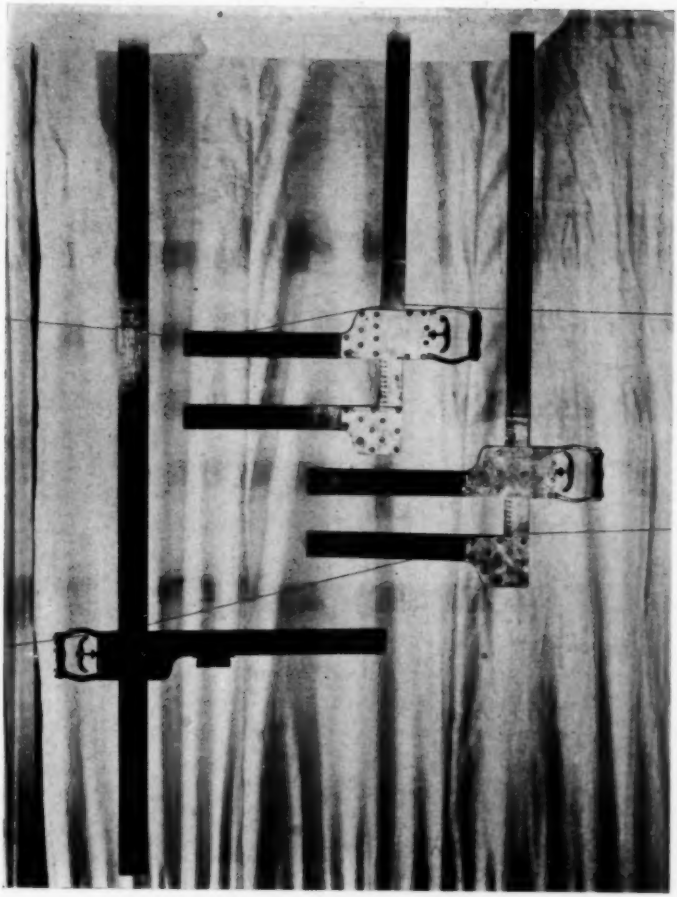

FIG. 1. STANDARD AND CALLIPERS FOR MEASURING CATTLE

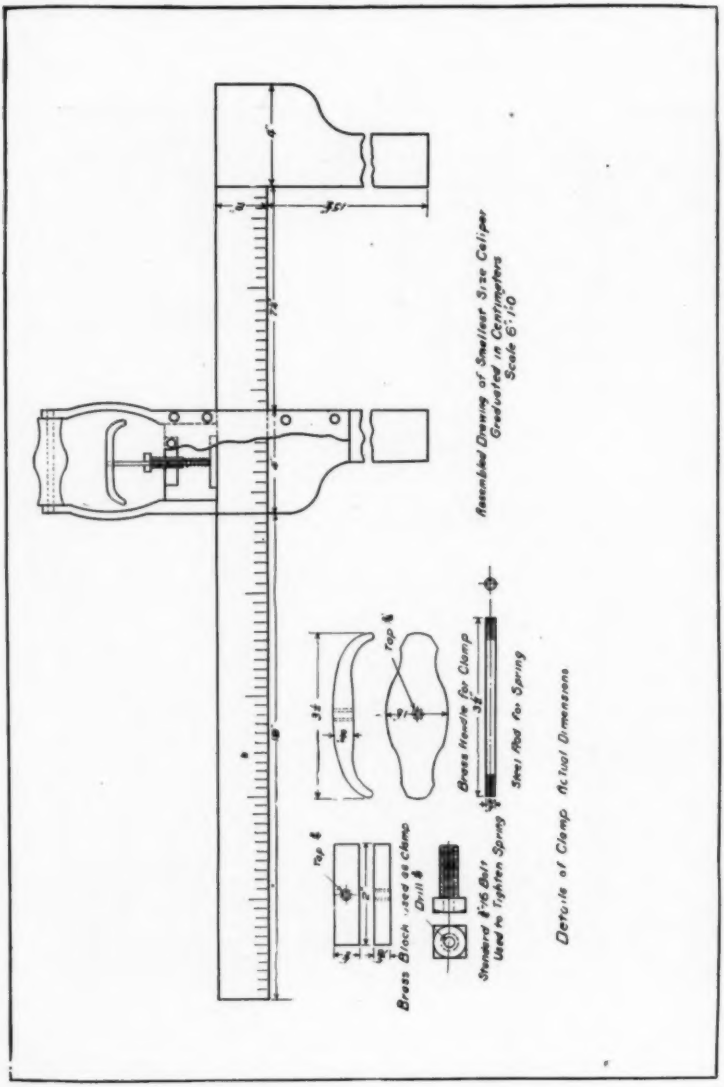
Assembled Drawing of Smaller Size Caliper
Graduated in Centimeters
Scale 6:1/0
Brass Handle for Clamp
Steel Rod for Spring
Details of Clamp Actual Dimensions
Brass Block used as clamp
Standard 6/0 Bolt
Used to tighten Spring

FIG. 2. DETAILS OF CLAMP FOR MOVEABLE CROSS-ARMS OF STANDARD AND CALLIPERS

the inner edge of the graduated bar to the tip. The clamp used on the moveable arm is similar to the one used on the Standard.

Small calliper. This is of the same type as the large calliper, the graduated bar being 75 cm. long and the cross arms 40 cm.

Details of clamp. Each cross-arm is held in place by two plates of $\frac{1}{8}$ inch brass riveted to the arm. These extend 2 inches behind the graduated bar and to them are attached two bars of $\frac{1}{2}$ by $\frac{3}{8}$ inch iron which support a cylindrical hand grip. These surround and support the clamp shown in detail in Figure 2.

A brass block 2 by $\frac{1}{2}$ by $\frac{5}{16}$ inch rests against the back of the graduated bar and into this is screwed a steel rod $\frac{5}{16}$ inch in diameter and $3\frac{1}{2}$ inches long. To the other end of this rod is attached a brass handle or finger grip for working the clamp. On the rod is a spiral spring the tension of which is controlled by a bolt 1 by $\frac{3}{8}$ inches. This bolt is screwed into an iron block $1\frac{3}{4}$ by $\frac{1}{2}$ by $\frac{1}{2}$ inch which is riveted between the brass plates supporting the cross-arm. A hole drilled through the bolt allows free passage for the $\frac{5}{16}$ inch rod.

It has been found that by using this standard for measuring the height of the animals at the withers, and the large callipers for obtaining the depth of chest and width at hooks of large animals, and the small callipers for getting similar measurements on smaller individuals excellent results can be obtained. The standard and callipers are strong but light enough to be conveniently handled. The clamp is especially satisfactory. In using the apparatus the hand grasps the large grip on the cross-arm and the small fingers grip on the clamp. This compresses the spring and releases the clamp. When the moveable arm is in the desired position the finger grip is released and this allows the spring to force the brass block into contact with the graduated bar, thus holding the cross-arm in position until the reading is taken.

SUGAR SAVING SUBSTITUTES IN ICE CREAM

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With the scarcity of sugar and the more and more stringent regulations by the United States Food Administrator regarding the use of sugar, the problem confronting the ice cream manufacturers in adjusting themselves to these regulations becomes more and more acute.

Ice creams are among our most desirable foods and it is hoped that the manufacturers of this desirable product will not be subjected to unnecessary hardships. However, at the present time, the saving of sugar is at once a public necessity and a patriotic duty, and it behooves every one interested in the ice cream industry to adopt such methods as will make it possible for him temporarily to meet changed conditions.

Since manufacturers are limited to 75 per cent of last year's consumption of sugar, and since most manufacturers expect a certain increase in business, it seems imperative that substitutes for something more than 25 per cent of the sugar previously used must be found.

Ayers, Johnson and Williams (1) of the U. S. D. A., in their work on "Sugar Substitutes in the Ice Cream Mix" found that grain syrups could not be successfully used as substitutes. The grain syrups gave a pronounced grain flavor and an acid taste when used to the extent of only 10 per cent. Regarding corn sugar, they found that satisfactory results were obtained with the following combination:

	pounds
Cane or invert sugar syrup	50
Corn syrup	50
Corn sugar	31¼

They, however, state that some grades of corn sugar imparted a yellow color and a bitter flavor.

Ruehe (2) worked on invert sugar and found that its sweetness is equal pound for pound to that of cane sugar. He used the following formula for making invert sugar syrup:

Sugar	100 pounds
Water	44 pounds
Tartaric acid	50 grams

These ingredients were mixed and boiled for thirty to thirty-five minutes. He found that boiling longer than thirty-five minutes causes the syrup to darken in color and this is somewhat objectionable. This solution boils at a temperature of 221°F.

The object of the investigation at the Nebraska Station was to work out some definite standard for an ice cream mix in which as much of the sugar as possible might be replaced by some suitable and desirable substitutes and yet maintain a high standard of quality. Most of the work herein reported was with corn syrup and corn sugar, although some experiments for other desirable sugar substitutes were also made.

The sweetening power of corn syrup as compared to cane sugar has been variously estimated by different investigators. Ayers, Johnson and Williams claim it to be one-half as sweet; Ruehe found it to be 60 per cent as sweet. Leach (3) states that it has about two-thirds the sweetening power of cane sugar, while some manufacturers consider that the corn syrup possesses only one-third as much sweetening properties.

It was found at this station that corn syrup is a good substitute in that it does not appreciably affect the flavor of the cream. When used in the proper proportions it imparts a rather delicate and desirable flavor. The consumers of the cream were frequently heard to remark, "This ice cream is exceptionally good." What is true of the flavor is also true as to the effect of the syrup on the body of the ice cream. The work so far as carried out at this time gives no indication of injury to body or texture, but rather seems to improve the texture.

Our experiments indicate a saving of 30 per cent of the cane sugar can be accomplished by the use of formula 1. If, however, greater quantities of corn syrup than indicated by the formula be

added, a rather pronounced "glucose" flavor is noticeable. (The term "cane sugar" includes both cane and beet sugar.) The following formula is now in use at the Station Dairy:

Formula 1

17 per cent cream	44	pounds[1]
Corn syrup (glucose)	1¾	pounds
Cane sugar	4	pounds
Vanilla extract	4	ounces
Gelatin	4	ounces

Ice cream from this formula has been sold commercially for several weeks, and as stated above, is liked by our regular trade. The mix, of course, is made in the usual way. The syrup dissolves with difficulty in cold cream. When, however, it is added to the cream before pasteurization, no trouble is encountered in bringing it into solution.

In our formula for a batch of mix the amount of sweetening material is equal by weight to 13 per cent of the weight of the cream used, or 11 per cent of the weight of the mix. From the above formula it may be seen that 70 per cent of cane sugar and thirty per cent of syrup are used to make up the required amount of sweetening. Ice cream makers who use more than the amount of sugar indicated in our formula will have to determine the percentage of syrup needed to suit their own conditions. Our judges and patrons when requested to give opinions considered the ice cream sweet enough. When a higher percentage of sweetening is used and it is thought desirable to reduce the amount, a gradual reduction would be less noticeable than a sudden change. The syrups on the market contain varying amounts of water and care must be taken, therefore, that the percentage of butterfat required by law is contained in the finished product.

CORN SUGAR

Corn sugar is a product made from corn. It is, according to Ayers, Johnson and Williams, 80 per cent as sweet as cane sugar.

[1] Finished ice cream would contain 14.3 per cent butterfat. The 4 ounces of gelatin is dissolved in 1 quart of water or preferably skimmed milk.

As stated previously in this work, all grades tried out by them were not equally satisfactory.

We worked with only one grade which was purchased from a local wholesale grocery house. It was very coarse and granular and did not dissolve easily when first put into the mix. After standing for thirty minutes it appeared to go into perfect solution. It had quite a marked yellow color but did not alter the natural color of the ice cream to any appreciable extent. We were unable to use corn sugar alone as the sweetening for the mix. It invariably gave a product too low in sweetening with a flat unpalatable flavor although it was never considered bitter. By increasing the amount of this sugar in the mix from 5.75 to 6.9 pounds the result was practically the same. After a number of trials it was quite evident that corn sugar in itself did not contain the desirable sweetening qualities for ice cream. In combination with cane sugar there was a marked improvement and it was found that the following formula with corn sugar gave a good satisfactory product.

Formula 2

17 per cent cream	44.0 pounds
Cane sugar	2.9 pounds
Corn sugar	2.9 pounds
Vanilla	4 ounces
Gelatin	4 ounces

The above formula shows that 50 per cent of the cane sugar is replaced by corn sugar. If more than that amount is used the resulting product tastes flat while with a 30 per cent substitution there is no apparent improvement in flavor and sweetness from that of the 50 per cent saving.

With a good grade of corn sugar, the manufacturer of ice creams can effect a saving of 50 per cent and still produce a good palatable product.

In following Ruehe's method, we used a candy kettle which was steam jacketed. By using steam under pressure it was easy to regulate the temperature so that an even and steady boiling was maintained for thirty-five minutes. The loss by evaporation was from 8 to 10 per cent when 28 pounds of sugar, 12

pounds of water and 14 grams of tartaric acid were used. The resulting invert sugar was good in taste and flavor, but when used in the mix in the same proportions as sugar it did not prove to be as sweet. Our experiments indicated that when invert sugar was used alone as the sweetening for ice cream, only 22 per cent of sugar could be saved. When used together with sugar and corn syrup, it proved an important step in sugar saving, as will be shown later.

We tried different proportions of invert sugar and corn syrup but invariably found that these two when combined and used as the only source of sweetening imparted to the ice cream a somewhat objectionable glucose flavor.

HYDROLYSIS OF CORN SYRUP

When the composition of corn syrup is considered it is found that it is a mixture of dextrin, maltose, and dextrose of the following composition (4):

	per cent
Dextrin	29.8 to 45.3
Maltose	4.6 to 19.3
Dextrose	34.3 to 36.5
Ash	0.32 to 0.52
Water	14.20 to 17.2

It was thought that by heating the corn syrup with tartaric acid some of the maltose and dextrin may be hydrolyzed to dextrose and thus increase the sweetening properties of the syrup.

METHOD OF HYDROLYSIS

One gram of tartaric acid was dissolved in 25 cc. of water. This was added to 2 pounds of syrup. The mixture was heated to boiling in a paraffin bath and boiled for twenty-five minutes.

The resulting product seemed sweeter to the taste than the original syrup. When added to the ice cream mix in quantities equal to that of unheated syrup it made the mix slightly sweeter. It was found however, that the hydrolyzed syrup imparted a syrupy flavor to the ice cream. The increase in sweetening

power was so slight that the extra expense of hydrolyzing is not considered justified. It is possible, however, that by some different process of hydrolysis a sweeter syrup and one with a less heated flavor may be obtained.

An analysis of hydrolyzed and non-hydrolyzed corn syrup gives the results shown in table 1.

It is seen from this table that the dextrin was not affected by the method of hydrolysis used. Only a small percentage of maltose seems to have been hydrolyzed to dextrose. Prolonged heating of the syrup at a low temperature may serve to increase the dextrose content to a still greater extent. It is possible that in this case the glucose flavor would also be decreased.

TABLE 1*

	NON-HYDROLYZED SYRUP	HYDROLYZED SYRUP
Dextrose	21.19	24.02
Maltose	26.44	21.80
Dextrin	34.68	34.56
Water	17.65	19.12
Specific gravity (Baume at 17.5°C.)	46.66	45.28

* This analysis made by Agricultural Chemistry Department.

"GLUCOSE INVERT" AS SUGAR SUBSTITUTE

It was thought possible to save time and labor by inverting the sugar and the corn syrup together.[2] This was tried and the method used was as follows:

One pound of corn syrup, 2 pounds of sugar, $\frac{3}{4}$ pound of water and 1 gram of tartaric acid were the proportions used in the preparation of this syrup. The mixture was heated to boiling in the candy kettle and allowed to boil gently at a constant temperature (224°F.) for thirty minutes. If boiled too vigorously a pronounced syrupy flavor resulted. This flavor becomes more noticeable when a greater amount of acid is used than that indicated above. It is, therefore, necessary that the process be

[2] For the sake of brevity we will refer to this mixture as "invert-syrup."

carefully carried out. By this method a syrup is obtained which dissolves quite readily in cold cream.

Some batches of mix were made in which invert syrup alone was used for sweetening. We found that when $5\frac{3}{4}$ pounds of it was used per batch the resulting cream was not sweet enough and it also possessed a slightly objectionable flavor. When the weight of invert syrup was increased to $6\frac{1}{4}$ pounds per batch, the cream was sweet enough. But this amount of the invert syrup masked the vanilla flavor and at the same time imparted an objectionably syrupy flavor.

When the invert syrup was used in combination with sugar a desirable product was obtained. We found the following formula to give a good ice cream:

Formula 3

17 per cent cream	44 pounds
Sugar	$1\frac{1}{2}$ pounds
Invert syrup	$4\frac{1}{2}$ pounds
Vanilla	4 ounces
Gelatin	4 ounces

Persons whom we asked to taste this cream pronounced it sufficiently sweet, and of good flavor. This formula, however, has not as yet been used by us on a commercial basis. We are, therefore, not in position to state how it will be considered by the regular trade. Insofar as sugar saving and cost are concerned, formula 3 is the most satisfactory. It saves 43 per cent sugar and the cost per gallon of mix is low (see table 2).

Another mix which possessed considerable merit was one in which a combination of invert sugar, sugar, and corn syrup was used. The proportions in the batch were as follows:

Formula 4

17 per cent cream	44 pounds
Corn syrup	$1\frac{1}{4}$ pounds
Invert sugar	$1\frac{1}{4}$ pounds
Sugar	$2\frac{1}{4}$ pounds
Gelatin	4 ounces
Vanilla	4 ounces

In sweetness, flavor, and body this cream equalled the two formulas previously described. As is the case with formula 3, we have not as yet used this formula commercially. By referring to table 2, it will be seen that this mix saves over 35 per cent sugar and lowers considerably the cost of sweetening per gallon.

TABLE 2

FORMULA	INGREDIENTS OF MIX	SUGAR SAVED	COST OF SWEETENING PER 10 GALLONS OF ICE CREAM	COST OF SWEETENING PER GALLON OF ICE CREAM
		per cent	*cents*	*cents*
1	44 pounds 17 per cent cream 4 pounds sugar 1¼ pounds corn syrup 4 ounces vanilla 4 ounces gelatin	30.43	43.2	4.32
2	44 pounds 17 per cent cream 2.9 pounds cane sugar 2.9 pounds corn sugar 4 ounces vanilla 4 ounces gelatin	50.00	44.225	4.423
3	44 pounds 17 per cent cream 1¼ pounds sugar 4⅓ pounds invert syrup 4 ounces vanilla 4 ounces gelatin	43.47	32.40	3.24
4	44 pounds 17 per cent cream 2¼ pounds sugar 1¼ pounds invert sugar 1¼ pounds corn syrup 4 ounces vanilla 4 ounces gelatin	36.52	40.52	4.052

SUMMARY

1. Four formulas have been worked out which save from 30 to 50 per cent of cane sugar in the mix.

2. The ice cream prepared according to these four formulas meets the requirements of good ice cream.

3. Corn syrup dissolves with difficulty in cold cream. When added to cream before pasteurizing, it dissolves readily.

4. In hydrolyzing the syrups, excessive heating should be avoided.

5. When invert sugar and corn syrup are used as the only source of sweetening, a rather noticeable syrupy flavor is imparted to the ice cream.

6. When invert sugar, cane sugar and corn syrup are used in the proportions indicated in formula 4, no objectionable flavor is noticeable.

7. It is thought that hydrolyzing corn syrup in the presence of an acid will enhance its sweetening properties.

8. In addition to saving cane sugar, all four formulas lower the cost of sweetening per gallon of ice cream.

9. Corn sugar can replace 50 per cent of cane sugar in the mix.

10. None of the substitutes so far tried will satisfactorily replace *all* the cane sugar in the ice cream mix.

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BUTTERMILK CHEESE

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The making of buttermilk cheese has received some attention in the past few years, as a means of utilizing all or a part of the largest creamery by-product in order to increase the income of the creamery. But under the existing condition of the food supply every creamery should eliminate the waste of any material which might serve as a foodstuff. Many creameries are so situated that they have a very poor or unprofitable outlet for their buttermilk and in most cases, due to bulk, the sale of this product is a local proposition. The buttermilk in such places should be converted into a product which can be shipped thereby increasing the market and preventing waste. Buttermilk cheese can be shipped or can be held in storage from a period of surplus to a time of shortage especially where the curd is used for poultry or pig feed. Good buttermilk from pasteurized or raw sweet cream will make a cheese equal in flavor and texture to that of a good grade of cottage cheese.

A number of methods have been described for the manufacture of buttermilk cheese but these do not give uniformly good results. The buttermilk from raw cream or pasteurized sweet cream is in most cases very easily handled as it simply requires development of acid, heating and draining on cloths, very often, however, there is a large loss of casein in the whey. With buttermilk from pasteurized sour cream, complete neutralization with caustic soda and re-acidifying with hydrochloric acid will make it possible to obtain the curd. This curd, however, has a peculiarly disagreeable flavor which clings to it even after repeated washings.

There is on the market at the present time a machine which extracts the curd from skim milk and buttermilk by centrifugal force. When making cheese from skim milk the procedure is the usual one, but instead of draining the curd on cloths the prepared

milk is run through the machine. The machine consists of a cylinder supported by a spindle and enclosed in an iron frame. This cylinder is 20 inches in diameter, 10 inches deep, with a $2\frac{1}{2}$-inch rim on top under which the whey and curd lodges, forming a wall. The curd being heavier forces its way to the outside and the whey runs over the rim, and after eight or ten cans have been run in a complete wall of curd will have formed.

FIG. 1. CENTRIFUGAL MACHINE FOR THE EXTRACTION OF CURD

The machine is then stopped and the curd taken out. If a smaller amount of material is to be run through, the machine should be allowed to run for seven to ten minutes after all of the milk is in, so that the curd will stand up against the side of the basket; then when the machine is stopped the surplus whey can be siphoned off.

A number of trials were made with this machine on buttermilk. The machine was speeded at 1700 revolutions per minute and the milk run in at the rate of from 13 to 20 pounds a minute.

The curd was weighed and the whey and buttermilk analyzed for casein and albumin. Several analyses were also made on the cheese. The casein left in the whey is a better index to the efficiency of the process than the mere consideration of the yield since enough whey or milk can be added to the curd to produce the desired yield, if all of the casein has been extracted. In this way a very uniform quality of cheese can be made since the moisture and texture of the curd will be about the same.

It was found that acidity, temperature and time of holding are the main factors influencing the completeness of extraction. The nature of the buttermilk influences the temperature at which it should be held before centrifuging. The curd from pasteurized sour cream buttermilk heated to 170°F. for an hour or more will not be coarse and gritty but will be fine and rather pasty, but if 140°F. for an hour has been used it will show more grain. Pasteurized sweet cream buttermilk held at 95 to 115°F. for one hour after the acid has reached 0.65 per cent produces the best curd for flavor and texture especially if from 2 per cent to 15 per cent starter is added and milk held at 75° until the desired degree of acid has been obtained. Such buttermilk, if the temperature is kept low, produces cheese equal to cottage cheese in flavor and texture.

It was apparent from the appearance of the whey, upon standing, that considerable more curd was lost when the buttermilk was run through without holding than when it was held for an hour at the same temperature.

TEMPERATURE	BUTTERMILK		WHEY	
	Casein*	Albumin*	Casein*	Albumin*
	per cent	*per cent*	*per cent*	*per cent*
140°—held one hour	2.69	0.197	0.319	0.197
170°—held one hour			0.266	0.110
170°—not held			0.397	0.170

* N × 6.38.

From the table which is an average of twelve runs it can be seen that the result of the higher temperature and holding not

only produces a more complete extraction of casein but that some of the albumin is also taken out. The percentage of casein left in the whey compares very favorably with that of cottage cheese whey which will show about 0.25 per cent casein. If the grain of the curd is of any importance 140°F. holding for one hour will give the best results.

Buttermilk, from pasteurized sweet cream, ripened to 0.65 per cent produced a very fine cheese and there was only 0.15 per cent casein left in the whey.

The operating of the machine and caring for the milk and cheese would take the entire time of one man while making a run. The machine is run by a 3 horse power motor which will utilize, figuring 1 kilowatt hour equal to $1\frac{1}{3}$ horse power, $2\frac{1}{4}$ kilowatts at 5 cents or 11 cents for power, labor 30 cents an hour, depreciation, etc., 14 cents, total 55 cents not counting cost of steam required for heating. With this method 100 pounds of curd an hour could be made so that the cost to manufacture a pound would be about $\frac{1}{2}$ cent.

	LOW	HIGH
Protein	23.84	29.51
Sugar	2.74	3.01
Fat	0.212	0.62
Ash	1.13	1.31

In order to get the comparative value of the cheese several analyses were made.

For hog feed based on present corn and tankage prices this would be valued at about $1.50 a 100, but for poultry feeding it should be worth considerably more. Calculating a yield of 10 pounds a 100 and $\frac{1}{2}$ cent for manufacture this would net from 10 to 25 cents a 100 pounds for the buttermilk, so that this would be a paying proposition where a large bulk was handled or the buttermilk a total waste. The whey would have some feeding value of course based on corn and tankage prices about 20 cents a 100 pounds, and if this could be disposed of there would be a return of from 25 to 40 cents a 100 pounds of buttermilk.

If the cheese is made from a good grade of buttermilk it can be used for human consumption and the income derived will be much larger. The important things are to find a good market, sell the cheese at a reasonable profit, and make a good uniform product. There are in most every city localities where people would be glad to get and would use large quantities of soft cheese if it could be had at a reasonable price. A neighborhood which consists mostly of foreign born people is one that will usually serve as a good outlet for such a good product.

THE UTILIZATION OF DAIRY BY-PRODUCTS

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Since the beginning of history, the blast of the horn has been a signal for action. The trumpet call of freedom leading our country into the world war upon the side of justice sounds again an appeal for action. And it must be concerted action in all fields of endeavor. We who stay at home must omit no action that will strengthen and comfort our people and their Allies.

War time needs have called our attention to many existing uneconomic practices which should be eliminated not only during the conflict, but in times of peace as well. Thrifty methods necessitated during this period should become a national routine. No country is rich enough to habitually practice wasteful methods and continue successful.

PREVENTION OF WASTES

There are two kinds of waste. The first may be called mechanical, and results in actual loss; the second consists of failure to use resources to the best advantage. Either type is deplorable. In our treatment of food products we have been guilty of permitting wastes in both ways. It is high time to call a halt, and the leaders in this must be those engaged in educational work with producers and handlers of food. The members of our association, then, may very profitably center their thought on the better utilization of dairy by-products. What would we think of the meat packer who threw away the tongues, livers, trimmings, etc? We would condemn him as wasteful; and yet we permit the waste of vast quantities of valuable food in the dairy industry. Dairymen themselves are not wholly to blame. They have not been taught proper methods of utilization. Furthermore, consumers are largely ignorant regarding the food value of skim milk and its products; hence the market demands have been limited.

Any campaign to reduce wastes of skim milk must have both objects in view; that of educating the consumer as to food values and uses in the dietary; and that of teaching dairymen how to manufacture the various by-products.

WASTE OF SKIM MILK

In the past much skim milk has been wasted both by throwing it away and by feeding it to farm stock when it could have been used to better advantage for human food. This does not mean that no skim milk should be fed to calves, hogs and chickens. Such a conclusion would be ridiculous, because our markets are not ready to absorb all the skim milk produced. But human needs should be cared for first, and only the surplus skim milk fed to live stock. Such a procedure is logical and is based on economic grounds. One hundred pounds of skim milk will produce from 15 to 19 pounds of cottage cheese. The same amount, when fed with corn to hogs, will produce only about 6 pounds of live weight or 4.8 pounds of dressed pork. Thus skim milk made into cottage cheese furnishes nearly seven times as much protein and about as much energy as the pork it would produce. Furthermore, in making cottage cheese from 100 pounds of skim milk, about 80 to 85 pounds of whey is recovered which has half the value of skim milk for hog feeding. This illustrates the fact that the greatest economy is to use food stuffs direct, rather than through domestic animals.

UTILIZATION OF BY-PRODUCTS

Dairy by-products may be utilized for human food in a number of ways. They may be consumed immediately to replace other articles in the diet; or they may be transformed into products that can be stored from periods of flush to be used in periods of shortage.

Skim milk and buttermilk without processing of any kind may be used for direct consumption as beverages or in cookery. We have not yet begun to realize the possibilities of the skim milk drinks such as buttermilk lemonade, prepared buttermilks,

koumiss and the like. They are pleasant and nutritious, in which respect they differ from many commonly used beverages.

The most available opportunity for the use of skim milk is through cottage cheese. I say "most available," because the manufacture of cottage cheese does not require elaborate equipment nor long training of operators. It can be quickly taught on any farm or in any factory where skim milk can be had, and this means almost anywhere. Furthermore, it can be consumed in fairly large quantities on the farm and in the immediate vicinity.

Protein is one of our expensive food constituents; yet skim milk contains a slightly higher percentage of it than does whole milk. It is estimated that the milk produced in the United States in 1917 contained about 11,000,000,000 pounds of solids. Of this amount about 3,400,000,000 pounds, or nearly one-third, was left in skim milk, buttermilk and whey during the manufacture of butter and cheese. What a tremendous amount of human food contained in the so-called by-products! If all the skim milk left from buttermaking in one year could be made into cottage cheese it would furnish over 900,000,000 pounds of protein; or nearly as much as is contained in all the beef consumed annually. This shows the possibility of partially replacing meat in the American home not only to benefit our pocketbooks but to release supplies for export.

Comparatively few people realize that a pound of cottage cheese, selling for 10 to 18 cents, contains as much protein as 1 to 1½ pounds of meat. It also furnishes as much energy as ⅓ to ¾ of a pound of meat. Cottage cheese may be used in cookery in a number of ways as a meat substitute. It may be prepared with vegetables as a "roast," served as a salad, etc. Where there are refrigeration facilities, cottage cheese may be frozen and stored for several months.

Let us consider for a moment some of the ways in which skim milk may be stored in flush periods to relieve shortage at other seasons. Condensed skim can be manufactured. It can be used in a number of ways by bakers, confectioners and ice cream makers.

Probably one of the greatest fields for the future lies in the manufacture of skim milk powder. We have as yet hardly begun to develop this industry which will provide a product capable of extensive storage, transportation at minimum cost, and utilization in a multitude of ways. It may be held over to meet seasonal shortages of production; or it may be shipped to localities where there is normally insufficient production. In combination with butter it may be used to reconstitute milk and cream for various purposes.

OTHER WASTES THAT SHOULD BE CHECKED

Many other wastes occur in the industry, all of which should be stopped. Whey from the average cheese factory probably contains about 0.2 per cent fat which can be recovered and used for the manufacture of whey butter. Milk sugar, albumen cheese and primost may also be made from whey.

It is true that the manufacture of some of these by-products requires large amounts of raw material and rather expensive apparatus. But the larger dairy establishments can well afford to make the investment; and there is opportunity for community development along this line.

PASTEURIZATION OF BY-PRODUCTS

Apparently little attention has been paid by the various states to the pasteurization of skim milk and whey. Certainly if these articles are to be used for human food, pasteurization is imperative; and if we are going to successfully combat the spread of animal diseases, all dairy by-products should be pasteurized. About a year ago I wrote to dairy officials in all the states to ascertain what laws were in effect regarding the pasteurization of skim milk and whey. Forty-five states replied and of these only six had such laws on the statute books. They were Colorado, Iowa, Maryland, Michigan, Minnesota and Pennsylvania. There is certainly work in the field for those interested in dairying in the other states.

OBSERVATIONS ON THE WASHING OF MILK CANS[1]

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The last container used for transporting milk between the milk shipper and the city dairy is the milk can. The invariable practice in the city in which this investigation was made was for the city dealer to wash the can before returning it to the shipper. Where the milk is shipped direct to the city dairy by the producer the milk remains in one can practically from the time it leaves the cow until it reaches the city. When the milk is handled through a receiving station two cans are used. The first belongs to the producer and holds the milk until it is delivered to the receiving station where it goes into a can belonging to the purchaser. Cleanliness is a prime requirement. A dirty can will contaminate the milk placed in it. In the case of the direct shipper the cans are washed, and in the larger city milk plants steamed, before they are returned to the producer. In the case of the receiving station, the practice varies. Producer's cans frequently are returned without even rinsing, thus the producer is required to care for the cans. In some instances the producer's cans are rinsed and hurriedly steamed while he waits for them. This investigation deals only with the handling of cans by the city dairy. The cans that transport the milk from the receiving station to the city milk plant are always washed by the latter.

This investigation covers the handling of the milk cans by 32 city dealers in one of the larger central western cities, and the condition of the cans as returned to the shipper. The shipper was either a receiving station or the producer.

[1] This paper presents a portion of the data obtained during an investigation of the milk supply of one of the large central western cities under the Food and Drugs Act. Published by permission of the Secretary of Agriculture. Mr. R. S. Smith of the Bureau of Animal Industry assisted in the collection of samples and in planning this piece of work which was finished and written up by Mr. Webster.

Of the 32 dealers investigated, 2 (D15 and D31) did not wash their cans but had them washed at another plant. The methods of washing practiced by the remaining 30 dealers as well as their can washing equipment varied very much.

The following summary of the methods and equipment has been prepared:

Summary of methods and equipment used in can washing of 32 city dairies

Wash their own cans	30
Wash cans in tank	22
Wash cans by pouring from can to can	8
Used warm water	29
Used hot water	1
Used clean water	2
Used dirty water	28
Used washing powder	29
Used brushes in washing	29
Brushed by hand	26
Brushed by machine	3
Brushed the cans thoroughly	1
Steamed the cans	23
Steamed the cans effectively	0
Drained the cans	17
Drained on the floor	10
Drained on a rack	7
While draining, exposed to flies and dust	5
Drained effectively	0
Dried the cans over air blast	3
Dried the cans effectively	1
Used disinfectants in cans	2
Washed cans satisfactorily	0
Had complete equipment[2]	3

It is interesting to note that only 22 out of 32 of the dealers used a tank and that 8 out of 32 washed the cans by pouring the washing solution from one can to the next. In almost every instance the water was used over and over until it was dirty. In only one instance was the water found to be uncomfortably hot to the touch. Only three of the dealers were equipped with mechanical brushes and in each instance these were found badly worn, dirty and greasy. In one instance the brushing was fairly

[2] Complete equipment considered to be tank with mechanical brush, running tank, steam jet and air blast.

thorough. Steaming the cans after washing was not universally practiced and in no instance carried out in an effective manner, that is, sufficiently long to sterilize the can. The average time was about seven to ten seconds. Only 17 of the dealers drained the cans at all. In 5 instances the cans were drained in such surroundings as to expose them to flies and dust. In no instance was the draining effective in drying the can. Only 3 of the dealers were equipped with a drying blast and only 1 of them used it effectively. Two of the dealers (D23 and D32) used a disinfectant; one after steaming the cans, one before steaming the cans. Three out of 30 dealers had an equipment that could be considered complete and even these 3 failed to make the washing process satisfactory or thorough. In all cases the work was hurried and careless. This was particularly true of the large dealers where the equipment was more satisfactory but where a large number of cans were washed.

In order to obtain information regarding the sanitary condition of the cans as returned by the city dealers to the shippers, cans were taken for examination at the city railroad stations either in the car or on the platform ready for loading. The time between the washing of the cans and testing was not determined but probably varied from a few hours to twenty-four hours or more.

EXAMINATION OF CANS

The physical condition of the interior of the can was first noted, *i.e.*, whether wet or dry and the odor classified as good, close, sour or foul. The amount of drain water was estimated in cubic centimeters, and this was sampled when present in sufficient amount. If the can was dry, or if the quantity of drain water was too small to sample, 200 cc. of sterile water were placed in the can and the interior rinsed by shaking and rolling the can. This rinse water was then sampled for bacterial count. Only total organisms on plain agar were determined. If the drain water was sampled, the count per cubic centimeter was multiplied by the estimated volume to secure the total number of bacteria in the can. This number was then divided by the volume

of the can, computed in cubic centimeters, in order to determine the probable contamination per cubic centimeter, if the can had been filled without rinsing. Where the rinse water was sampled the number of bacteria per cubic centimeter was multipled by 20 plus the estimated amount of drain water, if any was present, thus securing the total number of bacteria in the can. This figure was then divided by the volume of the can in the same way as stated above.

Table 1 gives the results obtained on 184 cans sampled during June and July.

An inspection of the complete table shows that a low calculated contamination is more frequently found in a dry can than in a wet can. This is not always the case for the reason that a freshly washed can will usually give a low count whether the interior is wet or dry.

The percentage of wet cans was 72.8; the amount of moisture varying from a few cubic centimeters to as much as 200 cubic centimeters.

The summary based on the physical condition of the cans agrees in certain points with the summary on "calculated contamination." First, 27.1 per cent of the cans were dry, while 27.2 per cent of the cans would give less than 1000 per cubic centimeter calculated contamination. Second, 52.7 per cent of the cans gave odors classified as "sour" or "foul," both indicative of bacterial activity, while 53.4 per cent of the cans examined would give a calculated contamination of 50,000 bacteria per cubic centimeter or more. That there is a real correlation between the physical condition of the cans and the number of bacteria present in the cans is shown by an analysis of the detailed tabulation of the results which shows that of the 50 dry cans 40 were found to have an odor classified as O.K., 3 were found to be close and 7 foul or sour. Upon bacteriological examination 33 gave a calculated contamination of less than 1000 per cubic centimeter, 5 ranged between 1000 and 10,000 per cubic centimeter, 4 between 10,000 and 25,000 per cubic centimeter, 1 between 25,000 and 50,000 per cubic centimeter, and 4 ranged above 50,000 per cubic centimeter.

TABLE 1

Summary of bacteriological investigation of empty milk cans returned to shippers

CANS EXAMINED	NUMBER	PER CENT
5-gallon cans	6	3.2
8-gallon cans	113	61.4
10-gallon cans	63	35.3
Total	184	

Physical condition of cans

	NUMBER	PER CENT
Interior of can:		
Wet	134	72.8
Dry	50	27.1
Contained flies	7	3.8
Odor of interior:		
O.K.	41	22.2
Close	46	25.0
Sour	14	7.6
Foul	83	45.1

Calculated contamination per cubic centimeter transmitted to milk if can is used without rinsing

BACTERIA PER CUBIC CENTIMETER	NUMBER	PER CENT
Less than 1,000	46	27.2
1,000 to 50,000	32	19.0
50,000 to 100,000	18	10.7
100,000 to 500,000	36	21.4
500,000 to 1,000,000	12	7.1
Over 1,000,000	24	14.2
Maximum, 4,332,000		
Total analyses	168	
Plates spoiled, or sample lost	16	

Of the 134 wet cans examined the odor of 5 was classified as O.K., 39 were close and 90 were foul or sour. Of these 130 were examined bacteriologically. Thirteen gave a calculated contamination of less than 1000 per cubic centimeter. Six ranged between 1000 and 10,000 per cubic centimeter. Six ranged

between 10,000 and 25,000 per cubic centimeter. Ten fell between 25,000 and 50,000 per cubic centimeter and 95 gave a calculated contamination exceeding 50,000 per cubic centimeter.

These figures are presented in tabulated form in table 2.

Thus these results show that 73 per cent of the wet cans will transmit an initial bacterial pollution to milk placed in them exceeding 50,000 bacteria per cubic centimeter, and only 3 per cent of these cans give an odor that can be classified as O.K. Of the dry cans, upon physical examination, 80 per cent gave

TABLE 2

	DRY CANS		WET CANS	
	Number	Per cent	Number	Per cent
Physical examination:				
Odor O.K.	40	80	5	3.7
Odor close	3	6	39	29.0
Odor foul or sour	7	14	90	67.1
Total	50	100	134	
Bacteriological examination:				
Less than 1,000 per cubic centimeter	33	70.2	13	10.0
1,000 to 10,000 per cubic centimeter	5	10.6	6	4.6
10,000 to 25,000 per cubic centimeter	4	8.5	6	4.6
25,000 to 50,000 per cubic centimeter	1	2.3	10	7.6
Over 50,00 per cubic centimeter	4	8.5	95	73.0
Total	47*	100.1	130†	99.8

* Three cans not examined bacteriologically that were examined physically.
† Four cans not examined bacteriologically that were examined physically.

odors that could be classified as O.K. and 70 per cent upon bacteriological examinations gave a calculated contamination of less than 1,000 organisms per cubic centimeter.

Dairy investigators have shown that milk even when produced under insanitary conditions seldom has an initial bacterial content exceeding 20,000 organisms per cubic centimeter. The dirty milk can may introduce more bacteria to the milk than is usually introduced by careless or slovenly methods of milking. In many instances the amount of filth introduced by the dirty can is

sufficient to throw the milk out of the Grade A class even if milked under the most approved conditions. It is interesting to note that the number of organisms used for starter purposes in certain types of cheese making does not exceed the numbers introduced by the dirty cans as determined in this investigation.

In order to determine whether the figures on bacteria per cubic centimeter obtained represented all or only a part of the bacteria really present, the following experiment was carried out.

Two freshly washed and steamed cans, each containing a small amount of drain water, were obtained from a local dairy and held

TABLE 3

SUBDIVISION	SIZE	DRAIN WATER	RINSE WATER	BACTERIA PER CUBIC CENTIMETER IN RINSE WATER
	gallons	*cc.*	*cc.*	
Can 1-a	10	20	200	200,000,000
Can b		None	200	53,000,000
Can c		None	200	25,000,000
Can d		None	200	20,000,000
Total bacteria obtained in four rinsings				298,000,000
Can 2-a	10	10	200	130,000,000
Can b		None	200	45,000,000
Can c		None	200	17,000,000
Can d		None	200	13,000,000
Total bacteria obtained in four rinsings				205,000,000

three days at room temperature, (approximately, 85–90°F.). The cans were then rinsed with 200 cc. sterile water four times successively with the results shown in table 3.

The first rinsing of can 1 gave 67 per cent of the total bacteria obtained in four rinsings, while in can 2, 63 per cent of the total of four rinsings were obtained. By the first rinsing this would indicate that the figures on bacteria as obtained by the method used in the investigation were at least 35 per cent or more below the actual figure.

The investigation shows that many of the milk cans returned to shippers are in very bad condition. Some of the cans are in

such shape that only a very thorough washing and scalding or steaming would put them into fit condition to receive milk. This is something that very few shippers are equipped to do, so it is necessary for the city dealer to remedy this condition.

The cause for these excessively high count cans during hot weather can be ascribed to a multiplication of the few bacteria left in the can after washing and steaming. This enormous development can only take place in a wet can. If the can is dried immediately after steaming, all development is absolutely prevented and the can will remain sweet and clean.

One of the city dealers under observation had attracted attention on account of the uniformly objectionable condition of the empty cans returned by him to his shippers. During the course of the investigation a can washing machine with attached air blast was installed at this factory. The following analyses were made prior to the change:

TABLE 4

CITY DEALER	DATE	ODOR	SIZE OF CAN	AMOUNT OF DRAIN	CALCULATED CONTAMINATION PER CUBIC CENTIMETER
			gallons	*cc.*	
D 21	June 26, 1916	Foul	10	75	23,700
		Sour	10	100	52,800
		Sour	10	150	178,000
		Foul	10	100	66,000
		Foul	10	100	Too numerous to estimate
D 21	June 27, 1916	Foul	10	50	88,000
		Foul	10	75	142,600
		Foul	10	50	11,800
		Foul	10	50	145,300
Average					88,500

After installing the apparatus, the analyses shown in table 5 were made on cans as delivered to the railroad.

The improved condition of the dried cans is very marked. That this is not due to the fact that the second lot may have consisted entirely of freshly washed cans is shown by the test in table 6.

TABLE 5

CITY	DATE	ODOR	SIZE OF CAN	AMOUNT OF DRAIN	CALCULATED CONTAMINATION PER CUBIC CENTIMETER
			gallons		
D 21	July 13, 1916	O.K.	10	Dry	53
		Close	10	Slight drain	52
		Close	10	Damp	52
		Close	10	Dry	52
		O.K.	10	Dry	158
		Close	10	Damp	52
		Close	10	Damp	52
		Close	10	Damp	634
		Close	10	Damp	105
		Close	10	Damp	158
		O.K.	10	Dry	52
		O.K.	10	Dry	52
Average					122

TABLE 6

SIZE OF CAN	CALCULATED CONTAMINATION	TIME OF STEAMING AND DRYING
Cans tested immediately after washing, steaming and drying		
gallons		
10	2	Steamed 7 seconds, dried 30 seconds.
10	17	
8	20	
8	400	
Average	109	
After holding for forty-eight hours at room temperature (approximately 85–95°F.)		
10	440	Steamed 7 seconds, dried 30 seconds.
10	320	Steamed 15 seconds, dried 30 seconds.
Average	380	

CONCLUSIONS

The investigation shows that the empty milk cans returned by the city dairies to the shippers constitute a serious source of contamination, in many instances the degree or amount of con-

tamination being sufficient to seriously injure or completely ruin milk even though produced under the most sanitary conditions.

The trouble is due to improper washing by the city dairies. As practiced at the time of this investigation the washing process left many cans with sufficient organic matter and moisture to support bacterial growth. The steaming, where practiced, in no instance really sterilized the can and the organisms remaining multiplied rapidly. The high temperatures prevalent with summer weather in this region further aided the development.

Only when the cans are effectively dried can this development be prevented. This may be quickly and economically done by exposing the cans after steaming and while still hot to an air blast. Thirty seconds' exposure is sufficient to bring about a marked improvement.

No dealer should be permitted to return filthy milk cans to the shipper if the milk he purchases is to be used as food.

The use of disinfectants in the cans should not be permitted under any circumstances. It is unnecessary, and further promotes slovenly and careless washing. There is also danger that the disinfectant may remain in sufficient amounts to be detected in the milk. This would make the shipper liable to criminal prosecution even though he did not know the cans had been disinfected with chemicals.

Proper washing of milk cans calls for the use of tanks of clean hot water and washing powder, with thorough brushing by hand or by machine. After washing cans should be rinsed in clean water and steamed for at least ten seconds. Such steaming will not sterilize the can but will reduce the number of bacteria and heat the can sufficiently to hasten drying in the air blast. Any blast of clean dry air delivered from a blower of sufficient volume to dry the can in from ten to thirty seconds may be used. An arrangement for heating the air will hasten drying by increasing the moisture carrying capacity of the air delivered. No system of handling the cans is complete unless the lids receive a thorough washing and drying. After drying the cans the lids are put on and the cans are ready to return to the shipper. The cans thus washed will remain sweet and clean indefinitely even in the hottest weather as there is no opportunity for bacterial activity in a dry can.

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